DESCRIPTION

IMAGE MATCHING METHOD, IMAGE MATCHING APPARATUS, AND PROGRAM

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TECHNICAL FIELD

[0001]　　　The present invention relates to an image matching method and an image matching apparatus for matching two images such as blood vessel images,

10 fingerprint images, still images or moving images, based on linear components within the images, and a program for the same.

BACKGROUND ART

[0002]　　　Conventionally, there is known various image

15 matching apparatuses as an apparatus for performing a matching images to an image information. For example, there is known an image matching apparatus in which a registered image and an image to be matched are compared based on a predetermined positional relationship,

20 correlation values thereof are calculated, and the matching of the registered image and the image to be matched are carried out based on the correlation values. Otherwise, in the case where the correlation values are generated, there is also known an image matching

25 apparatus in which the correlation values are generated

by an operation in every pixel unit.

DISCLOSURE OF THE INVENTION

PROBLEM TO BE SOLVED BY THE INVENTION

[0003]   However, in the above image matching

5   apparatus, if, there are pattern-grades such as many

linear components in the images even if a correlation of

the two images is small, and then there are many crossed

points of the linear components in the registered image

and the image to be matched, the crossed points greatly

10 contribute to the correlation value to increase the

correlation values, and, as a result, a sufficient

matching accuracy may not be obtain. So there is demanded

to improve the apparatus.

[0004]   The present invention was made in

15 consideration of the above discussions, and, an object of

the present invention is to provide an image matching

method, an image matching apparatus, and a program for

achieving an image matching at a high accuracy.

MEANS FOR SOLVING THE PROGRAM

20 [0005]   To achieve the above object, according to a

first aspect of the present invention, there is provided

an image matching method for performing a matching images

to linear components in a first image and a second image,

the method having: a first step of performing an image

25 processing for transforming points in each image of the

first image and the second image to a curved pattern and
transforming the linear component in the image to a
plurality of overlapped curved-patterns, based on a
distance from a reference position to a shortest point in
5   a straight line passing through a point in the image and
an angle between a straight line passing though the
reference position and the shortest point and a reference
axis including the reference position, and generating a
first transformed image and a second transformed image,
10   and a second step of performing a matching of the first
image and the second image based on a degree of an
overlap of the patterns in the first transformed image
and the second transformed image generated in the first
step and a matching or mismatching of the patterns in the
15   first and second transformed images.

[0006]   Further, to achieve the above object,
according to a second aspect of the present invention,
there is provided an image matching method for performing
a matching images to linear components in a first image
20   and a second image, the method having: a first step of
performing a Hough transform processing to the first
image and the second image to generate a first transform
image and a second transform image, and a second step of
performing a matching of the first image and the second
25   image based on a degree of an overlap of patterns in the

first transformed image and the second transformed image

generated in the first step and a matching or mismatching

of the patterns in the first and second transformed

images.

5   [0007]   Further, to achieve the above object,

according to a third aspect of the present invention,

there is provided an image matching apparatus performing

a matching images to linear components in a first image

and a second image, the apparatus having: a transform

10   means for performing an image processing to the first

image and the second image, by which points in each image

are transformed to a curved pattern and the linear

components in each image are transformed to a plurality

of overlapped curved-patterns based on a distance from a

15   reference position to a shortest point in a straight line

passing through a point in the image and an angle between

a straight line passing though the reference position and

the shortest point and a reference axis including the

reference position, and generating a first transformed

20   image and a second transformed image, and a matching

means for performing a matching of the first image and

the second image based on a degree of an overlap of the

patterns in the first transformed image and the second

transformed image generated by the transform means and a

25   matching or mismatching of the patterns in the first and

second transformed images.

[0008]   Further, to achieve the above object, according to a fourth aspect of the present invention, there is provided an image matching apparatus performing a matching images to linear components in a first image and a second image, the apparatus having: a transform means for performing a Hough transform processing to the first image and the second image to generate a first transformed image and a second transformed image, and a matching means for performing a matching of the first image and the second image based on a degree of an overlap of patterns in the first transformed image and the second transformed image generated by the transform means and a matching or mismatching of the patterns in the first and second transformed images.

[0009]   Further, to achieve the above object, according to a fifth aspect of the present invention, there is provided a program that causes an information processing device to perform a matching images to linear components in a first image and a second image, the program having: a first routine for performing an image processing to the first image and the second image, by which points in each image are transformed to a curved pattern and linear components in each image are transformed to a plurality of overlapped curved-patterns

based on a distance from a reference position to a shortest point through a point in the image toward a straight line and an angle between a straight line passing though the reference position and the shortest

5 point and a reference axis including the reference position, and generating a first transformed image and a second transformed image, and a second routine for performing a matching of the first image and the second image based on a degree of an overlap of the patterns in

10 the first transformed image and the second transformed image generated in the first routine and a matching or mismatching of the patterns in the same.

[0010] Further, to achieve the above object, according to a sixth aspect of the present invention,

15 there is provided a program that causes an information processing device to perform a matching images to linear components in a first image and a second image, the program having: a first routine for performing a Hough transform processing to the first image and the second

20 image to generate a first transformed image and a second transformed image, and a second routine for performing a matching of the first image and the second image based on a degree of an overlap of patterns in the first transformed image and the second transformed image

25 generated in the first routine and a matching or

mismatching of the patterns in the first and second

transformed images.

[0011]   According to the present invention, in the

first step and in the first routine, a step transform

5   means performs an image processing for transforming

points in each image of the first image and the second

image to a curved pattern and transforming linear

components in each image to a plurality of overlapped

curved-patterns, based on a distance from a reference

10   position to a shortest point in a straight line passing

through a position in the image and an angle between a

straight line through the reference position and the

shortest position and a reference axis including the

reference position, and generating the first transformed

15   image and the second transformed image.

In the second step and in the second routine, the

matching means matches the first image and the second

image, based on the degree of the overlap of the patterns

in the first transformed image and the second transformed

20   image generated by the transform means and a matching or

mismatching of the patterns in the first and second

transformed images.

EFFECT OF THE INVENTION

[0012]   According of the present invention, there is

25   provided an image matching method, an image matching

apparatus, and a program, enabling the image matching at a high accuracy.

BRIEF DESCRIPTION OF THE DRAWINGS

[0013]   [FIG. 1] FIG. 1 is a functional block diagram illustrated in a form of hardware of an image matching apparatus of a first embodiment according to the present invention.

[FIG. 2] FIG. 2 is a functional block diagram illustrated in a form of software of the image matching apparatus shown in FIG. 1.

[FIG. 3] FIGs. 3A and 3B are views for explaining an operation of a Hough transform unit shown in FIG. 2.

[FIG. 4] FIGs. 4A to 4F are views for explaining the operation of the Hough transform unit shown in FIG. 2.

[FIG. 5] FIGs. 5A to 5C are views for explaining an operation of a similarity generation unit shown in FIG. 2.

[FIG. 6] FIG. 6 is a flow chart for explaining an operation of the image matching apparatus according to the present embodiment shown in FIG. 1.

[FIG. 7] FIG. 7 is a view showing a position correction unit of an image matching apparatus of a second embodiment according to the present invention.

[FIG. 8] FIG. 8 is a view for explaining an operation of a Fourier and Mellin transform unit 211 shown in FIG. 7.

[FIG. 9] FIGs. 9A to 9F are views for explaining different points between a self-correlation method and a phase-only correlation method.

[FIG. 10] FIGs. 10A to 10C are views for explaining correlation intensity distributions in the phase-only correlation method in the case where a parallel movement shift exists between two images.

[FIG. 11] FIGs. 11A to 11C are views for explaining correlation intensity distributions in the phase-only method in the case where a rotation shift exists between two images.

[FIG. 12] FIGs. 12A to 12C are views for explaining correlation image data output by a phase-only correlation unit 23.

[FIG. 13] FIG. 13 is a view for explaining the correlation image data shown in FIG. 12C.

[FIG. 14] FIG. 14 is a flow chart for explaining an operation of the image matching apparatus 1 shown in FIG. 1.

[FIG. 15] FIG. 15 is a functional block diagram of an image matching apparatus of a third embodiment according to the present invention.

[FIG. 16] FIGs. 16A and 16B are views for explaining an operation of a position correction unit shown in FIG. 15.

[FIG. 17] FIG. 17 is a flow chart for explaining an operation of the image matching apparatus of the third embodiment according to the present invention.

[FIG. 18] FIG. 18 is a functional block diagram of an image matching apparatus of a fourth embodiment according to the present invention.

[FIG. 19] FIGs. 19A to 19F are views for explaining an operation of the image matching apparatus 1c shown in FIG. 17; FIG. 19A is a view showing a specific example of an image IM11; FIG. 19B is a view showing an image in which a region equal to or greater than a first threshold is extracted from the image IM11 shown in FIG. 19A; FIG. 19C is a view showing an image in which a region equal to or greater than a second threshold larger than the first threshold is extracted from the image IM11 shown in FIG. 19A; FIG. 19D is a view showing a specific example of an image IM12; FIG. 19E is a view showing an image in which a region equal to or greater than a first threshold is extracted from the image IM12 shown in FIG. 19D; and FIG. 19F is a view showing an image in which a region equal to or greater than a second threshold, larger than the first threshold, is extracted from the image IM11 shown in FIG. 19D.

[FIG. 20] FIG. 20 is a flow chart for explaining an operation of the image matching apparatus according to

the present embodiment.

[FIG. 21] FIG. 21 is a flow chart for explaining an operation of an image matching apparatus of a fifth embodiment according to the present invention.

5   [FIG. 22] FIG. 22 is a flow chart for explaining an operation of an image matching apparatus according to a sixth embodiment according to the present invention.

BEST MODE FOR CARRYING OUT THE INVENTION

[0015]   FIG. 1 is a functional block diagram

10   illustrated in a form of hardware of an image matching apparatus of a first embodiment according to the present invention.

An image matching apparatus 1 according to the present embodiment, as shown in FIG. 1, has an image

15   input unit 11, a memory 12, a FFT processing unit 13, a coordinates transform unit 14, a Hough transform unit 15, a CPU 16, and an operation processing unit 17.

For example, the image input unit 11 is connected to the memory 12. The memory 12, the FFT processing unit

20   13, the coordinates transform unit 14, the Hough transform unit 15, and the CPU 16 are connected by a bus BS. The operation processing unit 17 is connected to the CPU 16.

[0016]   The image input unit 11 functions as an input

25   unit for inputting an image from the outside. For example,

a registered image AIM and an image to be compared with

the registered image AIM (referred to an image to be

matched RIM, also) are input to the image input unit 11.

The memory 12, for example, stores an image input

5   from the image input unit 11. The memory 12 stores the

registered image AIM, the image to be matched RIM, and a

program PRG as shown in FIG. 1.

The program PRG is executed, for example, by the

CPU 16, and includes routines for realizing functions

10 concerning a transform processing, a correlation

processing, and a matching processing, according to the

present invention.

[0017]   The FFT processing unit 13, for example under

control of the CPU 16, performs a two-dimensional Fourier

15 transform processing to an image stored in the memory 12,

for example, and outputs the processed result to the

coordinates transform unit 14 and the CPU 16.

[0018]   The coordinates transform unit 14, for

example under control of the CPU 16, performs a

20 logarithm-polar coordinates transform processing to the

result of the two-dimensional Fourier transform

processing performed by the FFT processing unit 13, and

outputs the coordinates transformed result to the CPU 16.

The operation processing unit 17 performs a

25 predetermined processing such as a release of an

electric-key in the case where the registered image AIM

and the image to be matched RIM are matched, for example,

based on the processed result by the CPU 16 as mentioned

later.

5   [0019]   The Hough transform unit 15 performs a Hough

transform processing as mentioned later under control of

the CPU 16, and outputs the processed result to the CPU

16. The Hough transform unit 15 is preferably used with

an exclusive circuit formed by a hardware in order to

10   perform, for example, the Hough transform processing at a

high speed.

[0020]   The CPU 16 performs a matching processing to

the registered image AIM and the image to be matched RIM

stored in the memory 12, for example, based on the

15   program PRG according to the present embodiment of the

present invention. The CPU 16 controls, for example, the

image input unit 11, the memory 12, the FFT processing

unit 13, the coordinates transform unit 14, the Hough

transform unit 15, and the operation processing unit 17,

20   to realize the operation according to the present

embodiment.

[0021]   FIG. 2 is a functional block diagram

illustrated in a form of a software of the image matching

apparatus shown in FIG. 1.

25   For example, the CPU 16 executes the program PRG

stored in the memory 12 to realize functions of a

position correction unit 161, a Hough transform unit 162,

an extraction unit 163, and a judgment unit 164 as shown

in FIG. 2.

5   The position correction unit 161 corresponds to a

position correction means according to the present

invention, the Hough transform unit 162 corresponds to a

transform means according to the present invention, the

extraction unit 163 corresponds to an extraction means

10   according to the present invention, and the judgment unit

164 corresponds to a matching means according to the

present invention.

[0022]   The position correction unit 161, for example,

corrects a positional shift to an image pattern in the

15   registered image AIM and the image to be matched RIM

stored in the memory 12 in a right and left direction and

an up and down direction, an enlargement ratio, and a

rotation angle shift of the two images, and outputs the

corrected image to the Hough transform unit 162.

20   In detail, for example, the positional correction

unit 161 performs a position correction processing to the

registered image AIM and the image to be matched RIM and

outputs the result as signals S1611 and S1612 to the

Hough transform unit 162.

25   [0023]   The Hough transform unit 162, for example,

executes the Hough transform processing in the Hough transform unit 15 performing the exclusive Hough transform processing in hardware.

In detail, for example, the Hough transform unit

5   162 performs the Hough transform processing to the signal S1611 which is the registered image AIM to which the position correction processing was performed, and outputs the processing result as the signal S1621.

The Hough transform unit 162 performs the Hough

10   transform processing to the signal S1612 which is the image to be matched RIM to which the position correction processing was performed, and outputs the result as a signal S1622.

[0024]   FIGs. 3A and 3B are views for explaining an

15   operation of the Hough transform unit shown in FIG. 2.

The Hough transform unit 162 performs an image processing, for example, to the first image and the second image respectively, by which the points in each image are transformed to curved patterns and by which

20   linear components in each image are transformed to a plurality of overlapped curved patterns, based on a distance $\rho 0$ from a reference position $\underline{O}$ to a shortest point P0 in a straight line L0 passing through a point in the image and an angle θ between a straight line n0

25   passing though the reference position $\underline{O}$ and the shortest

point P0 and a reference axis including the reference

position O, to thereby generate a first transformed image

and a second transformed image.

[0025]   For simplifying explanations, for example, as

shown in FIG. 3A, it is assumed that, in an x-y plane,

there is the straight line L0, and a position P (x1, y1),

a position P2 (x2, y2), and a position P3 (x3, y3) on the

straight line L0.

It is assumed that a straight line through the

origin O and perpendicular to the straight line L0 is the

line n0, so the straight line n0 and the x-axis as the

reference axis are crossed at an angle θ0 and that the

origin O and the straight line L0 are separated with a

distance $|\rho0|$, for example. Here, $|\rho0|$ indicates the

absolute value of $\rho0$. The straight line L0 can be

expressed by parameters $(\rho0, \theta0)$.

The Hough transform processing performed to

coordinates (x, y) in the x-y plane, is defined by

formula (1), for example.

[0026]

[Formula 1]

$$\rho = x \cdot \cos\theta + y \cdot \sin\theta \qquad \qquad \ldots (1)$$

[0027]   For example, when the Hough transform

processing expressed by the formula (1) is performed to

the positions P1, P2, and P3, the positions P1, P2, and

P3 are transformed to curved lines in a ρ-θ space as shown in FIG. 3B. In detail, by the Hough transform processing, the point P1(x1, y1) is transformed to a curved line PL1(x1·cosθ + y1·sinθ), the point P2(x2, y2)

5   is transformed to a curved line PL2(x2·cosθ + y2·sinθ), and the point P3(x3, y3) is transformed to a curved line PL3(x3·cosθ + y3·sinθ).

Patterns of the curved lines (curved patterns) PL1, PL2, and PL3 are crossed at a crossed point CP(ρ0, θ0) in

10   the ρ-θ space. The crossed point P(ρ0, θ0) in the ρ-θ space corresponds to the linear component L0 in the x-y space.

Conversely, as shown in FIG. 3A, the linear component L0 on the x-y plane corresponds to the crossed

15   point CP of the curved patterns PL1, PL2, and PL3 on the ρ-θ space.

[0028]   As described above, the Hough transform processing is performed to a two-binary image, it may judge which linear components dominates in the x-y plane

20   before the transform processing, based on the degree of the overlap of the curved patterns in the above resultant ρ-θ space.

[0029]   FIGs. 4A to 4F are views for explaining an operation of the Hough transform unit shown in FIG. 2.

25   The Hough transform unit 162 performs the Hough

transform processing to the registered image AIM to which

the position correction processing was performed, shown

in FIG. 4A for example, to generate the image S1621 shown

in FIG. 4C, and performs the Hough transform processing

5   to the image to be matched RIM to which the position

correction processing was performed, shown in FIG. 4B, to

generate the image S1622.

In the respective pixels included in the images

S1621 and S1622, a value corresponding to the degree of

10   the overlap of the curved patterns is set. In the present

embodiment, in the images to be displayed based on a

predetermined gradation, a pixel(s) in which the degree

of the overlap of the curved patterns is large, is

displayed in white.

15   As mentioned later, the matching unit 1642 performs

a matching processing based on the degree of the overlap

of the curved patterns, so it performs the matching

processing based on the linear component in the original

x-y space.

20   [0030]   The extraction unit 163, from the respective

first transformed image and the second transformed image,

extracts regions each of which indicates the degree of

the overlap of the curved patterns in the transformed

image equal to or greater than a threshold set in advance.

25   In detail, the extraction unit 163, for example,

extracts the region of which the degree of the overlap of

the curved patterns in the transformed image is equal to

or greater than the threshold set in advance, from the

signal S1621 as the first transformed image shown in FIG.

5   4C, generates an image S1631 shown in FIG. 4E, and

outputs the same to the matching unit 1642.

Also, the extraction unit 163, for example,

extracts the region of which the degree of the overlap of

the curved patterns in the transformed image is equal to

10 or greater than the threshold set in advance, from the

signal S1622 as the second transformed image shown in FIG.

4D, generates an image S1632 shown in FIG. 4F, and

outputs the same to the matching unit 1642.

By performing the extraction processing, for

15 example, noise components different from the linear

components in the registered image AIM and the image to

be matched RIM, in the x-y space, for example, point

components, are deleted.

[0031]   The judgment unit 164 performs the matching

20 of the first image and the second image based on the

degree of the overlap of the patterns in the first

transformed image and the second transformed image and a

matching or mismatching of the patterns in the two images.

In detail, the judgment unit 164 performs the

25 matching, for example, to the signal S1631 and the signal

S1632, and outputs the matched result as a signal S164.

[0032]   The judgment unit 164, for example, as shown

in FIG. 2, has a similarity generation unit 1641 and a

matching unit 1642.

5   The similarity generation unit 1641, for example,

performs a comparison processing to a plurality of

different positional relationships in the first

transformed image and the second transformed image, and

generates a similarity as the correlation value based on

10   the compared result.

In detail, the similarity generation unit 1641, for

example, performs the comparison processing to a

plurality of different positional relationships in the

two images of the signal S1631 and the signal S1632, and

15   generates the similarity as the correlation value based

on the compared result.

[0033]   For example, the similarity generation unit

1641, assuming the two images as f1(m, n) and f2(m, n),

calculates a similarity Sim by applying the following

20   formula (2) and outputs the result as S1641.

[0034]

[Formula 2]

$$\text{Sim}(f1,f2) = \frac{\sum_{m=0}^{M-1} \sum_{n=0}^{N-1} f1(m,n)\, f2(m,n)}{\sqrt{\{\sum_{m=0}^{M-1} \sum_{n=0}^{N-1} f1(m,n)^2\}} \sqrt{\{\sum_{m=0}^{M-1} \sum_{n=0}^{N-1} f2(m,n)^2\}}}$$

$$\ldots (2)$$

[0035]   FIGs. 5A to 5C are views for explaining an

operation of the similarity generation unit shown in FIG.

2.

The similarity generation unit 1641, for example,

in the case where the similarity of two images including

linear components (also, referred to linear shapes) shown

in FIGs. 5A and 5B is generated, generates the similarity

corresponding to a number of the crossed points CP of the

two images as shown in FIG. 5C. Here, for simplifying

explanations, the linear components are indicated by

black pixels of a bit value '1' and others are indicated

by white pixels of a bit value '0'.

[0036]   The matching unit 1642 performs the matching

of the image to be matched RIM and the registered image

AIM based on the signal S1641 indicating the similarity

generated by the similarity generation unit 1641.

For example, the matching unit 1642 judges that the

registered image AIM and the image to be matched RIM are

matched in the case where the similarity is larger than a

predetermined value.

[0037]   FIG. 6 is a flow chart for explaining an

operation of the image matching apparatus according to

the present embodiment shown in FIG. 1. While referring

to FIG. 6, the operation of the image matching apparatus,

5   mainly an operation of the CPU, will be described.

[0038]   For example, the registered image AIM and the

image to be matched RIM are input from the image input

unit 11, and the memory 12 stores the respective input

data.

10   At step ST101, for example as shown in FIG. 2, the

position correction unit 161 performs the position

correction processing based on the image patterns in the

registered image AIM and the image to be matched RIM

stored in the memory 12, in detail, corrects a positional

15   shift in a right and left direction and an up and down

direction, a magnification ratio, and the rotation angle

shift in the two images, and outputs the corrected images

as the signals S1611 and S1612 to the Hough transform

unit 162.

20   [0039]   At step ST102, the Hough transform unit 162,

for example, performs the image processing to the signal

S1611 being the registered image AIM to which the

position correction processing was performed shown in FIG.

4A, the image processing transforming the positions in

25   each image to the curved pattern PL and the linear

components L in each image to a plurality of the

overlapped curved patterns PL as shown in FIG. 3A, based

on the distance ρ0 from the reference position O to the

shortest point P0 in the straight line L0 passing through

5   the point in the image and the angle θ between the

straight line n0 passing through the reference position O

and the shortest point P0 and the x-axis as the reference

axis including the reference position O, to generate the

signal S162 as the transformed image in the ρ-θ space as

10   shown in FIG. 4C.

The Hough transform unit 162 performs the Hough

transform processing, in the same way, to the signal

S1612 being the image to be matched RIM to which the

position correction processing was performed as shown in

15   FIG. 4B, to generate the signal S1622 as the transformed

image in the ρ-θ space as shown in FIG. 4D, for example.

[0040]   At step ST103, the extraction unit 163

extracts the regions each of which indicates the degree

of the overlap of the curved patterns in the transformed

20   image equal to or greater than the threshold set in

advance, from the transformed image S1621 and the

transformed image S1622 respectively.

In detail, as described above, the value

corresponding to the degree of the overlap of the curved

25   patterns is set in the respective pixels in the images

S1621 and S1622, and in the image to be displayed based on a predetermined gradation, portions of which the degree of the overlap of the curved patterns are high, are displayed in white.

5   The extraction unit 163, for example, extracts the region of which the degree of the overlap of the curved patterns in the transformed image S1621 shown in FIG. 4C is equal to or greater than the threshold set in advance, generates the image S1631 shown in FIG. 4E for example, 10   and outputs the same to the matching unit 1642.

The extraction unit 163, for example, extracts the region of which the degree of the overlap of the curved patterns in the transformed image S1622 shown in FIG. 4D is equal to or greater than the threshold set in advance, 15   generates the image S1632 shown in FIG. 4F for example, and outputs the same to the matching unit 1642.

[0041]   The matching unit 1642 performs the matching of the image to be matched RIM and the registered image AIM based on the degree of the overlap of the patterns in 20   the transformed images S1631 and S1632 and the matching or mismatching of the patterns in the transformed images S1631 and S1632.

[0042]   In detail, at step ST104, the similarity generation unit 1641 performs the comparison processing 25   to a plurality of the different positional relationships

in the transformed images S1631 and S1632, generates the

similarity Sim as the correlation value based on the

compared result, for example, as expressed by the formula

(2), and outputs the same as the signal S1641.

5   [0043]   At step ST105, the matching unit 1642

performs the matching of the image to be matched RIM and

the registered image AIM based on the similarity Sim

functioning as the correlation value generated by the

similarity generation unit 1641. In detail, the matching.

10   unit 1642 judges that the registered image AIM and the

image to be matched RIM are matched in the case where the

similarity Sim is greater than the threshold set in

advance, otherwise judges that they are mismatched in the

case where the similarity Sim is equal to or less than

15   the threshold.

For example, the operation processing unit 17

performs a predetermined processing such as release of an

electric-key in the case where the image matching

apparatus according to the present embodiment is applied

20   to a vein pattern matching apparatus in a security field.

[0044]   As described above, the matching apparatus is

provided with: the Hough transform unit 15 performing the

Hough transform processing to the registered image AIM

and the image to be matched RIM respectively, in detail,

25   performing the image processing to the registered image

AIM and the image to be matched RIM, by which the points

in each image are transformed to the curved pattern PL

and the linear components in each image are transformed

to a plurality of the overlapped curved-patterns PL based

5   on the distance ρ from the reference position O to the

shortest point P0 in the straight line L passing through

the point in the image and the angle θ between the

straight line n0 passing through the reference position O

and the shortest point P0 and the x-axis as the reference

10   axis including the reference position O, and generating

the transformed image S1621 and the transformed image

S1622; and the judgment unit 164 performing the matching

of the image to be matched RIM and the registered image

AIM based on the degree of the overlap of the patterns in

15   the transformed image S1621 and the transformed image

S1622 generated by the Hough transform unit 15 and the

matching or mismatching of the patterns in the

transformed image S1621 and the transformed image S1622.

So, the matching images including the featured linear

20   components can be performed at a high accuracy.

[0045]   Namely, the Hough transform unit 15 generates

the transformed images under consideration of the linear

components (also, referred to a linear shapes) in the

registered image AIM and the image to be matched RIM by

25   performing the Hough transform processing, and the

judgment unit 164 performs the matching of the

transformed images based on the degree of the overlap of

the curved patterns. So, the matching images including

the featured linear components can be performed at a high

5 accuracy.

[0046]   Further, if the extraction unit 163 is

provided at a subsequent stage of the Hough transform

unit 162, the extraction unit 163 extracts the region of

which the degree of the overlap of the curved patterns PL

10 in either the transformed image S1621 or the transformed

image S1622 is equal to or greater than the threshold set

in advance, namely, deletes point components functioning

as noise components on the registered image AIM and the

image to be matched RIM and extracts only the linear

15 components, and generates the images S1631 and S1632, and

the judgment unit 164 performs the matching of the image

to be matched RIM and the registered image AIM based on

the matching or mismatching of the patterns in the

extracted region. Consequently, the matching processing

20 further improved and at a higher accuracy can be

performed.

[0047]   And, the judgment unit 164 is provided with:

the similarity generation unit 1641 performing the

comparison processing to a plurality of the different

25 positional relationships in the transformed images, and

generating the similarity Sim as the correlation value

based on the compared result; and the matching unit 1642

performing the matching of the image to be matched RIM

and the registered image AIM based on the generated

5   similarity Sim. Then, the judgment unit 164 generates the

similarity as the correlation value by applying a simple

calculation and performs the matching processing based on

the similarity. Consequently, the matching processing can

be performed at a high speed.

10   [0048]   In the present embodiment, though the

position correction processing is performed at step ST101,

but, it is not limited thereto. For example, in the case

where the position correction processing is unnecessary,

the Hough transform unit 15 may perform the Hough

15   transform processing to the registered image AIM and the

image to be matched RIM respectively. Therefore, a

processing load is reduced and the matching processing

can be performed at a high speed.

[0049]   In the present embodiment, though, at step

20   ST103, the extraction unit 163 extracts the region of

which the degree of the overlap of the curved patterns PL

is equal to or greater than the threshold set in advance,

but, it is not limited thereto.

For example, the extraction unit 163 dose not

25   perform the extraction processing, and the judgment unit

164 may perform the matching of the image to be matched RIM and the registered image AIM based on the degree of the overlap of the patterns in the image S1621 and the image S1622 and the matching or mismatching of the

5   patterns therein. Therefore, the processing load is reduced and the matching processing can be performed at a high speed.

[0050]   FIG. 7 is a block diagram showing a position correction unit of the image matching apparatus of a

10   second embodiment according to the present invention.

The image matching apparatus 1a according to the present embodiment, in a functional block diagram illustrated as a hardware, has approximately the same configuration as the image matching apparatus 1 according

15   to the first embodiment, and, for example, has the image input unit 11, the memory 12, the FFT processing unit 13, the coordinates transform unit 14, the Hough transform unit 15, the CPU 16 and the operation processing unit 17 as shown in FIG. 1.

20   In the functional block illustrated as a software, the image matching apparatus 1a has approximately the same configuration as the image matching apparatus 1 according to the first embodiment, and the CPU 16 executes the program PRG to realize the function of the

25   position correction unit 161, the Hough transform unit

162, the extraction unit 163, and the judgment unit 164.

Components the same as those of the above

embodiment are assigned the same notations (references)

and explanations thereof are omitted. And only different

5   points will be described.

[0051]   The different points are the followings: the

position correction unit 161, as a position correction

processing, generating the correlation value based on

phase components which are results of the rotation angle

10 correction processing of the registered image AIM and the

image to be matched RIM or the enlargement ratio

correction processing thereof, and the Fourier transform

processing thereof, and performing the position

correction processing to the registered image AIM and the

15 image to be matched RIM based on the generated

correlation value.

In detail, the position correction unit 161

according to the present embodiment, as shown in FIG. 7,

realizes functions of the magnification information and

20 rotation information unit 21, the correction unit 22, the

phase-only correlation unit 23, the shift information

generation unit 24, and the correction unit 25 by the CPU

16 executing the program PRG and controlling the FFT

processing unit 13 and the coordinates transform unit 14,

25 for example.

[0052]   The magnification information and rotation

information unit 21 and the correction unit 22 perform a

rotation angle correction processing or an enlargement

ratio correction processing thereof to the registered

5   image AIM and the image to be matched RIM.

The magnification information and rotation

information unit 21 generates a magnification information

and/or a rotation information based on the registered

image AIM and the image to be matched RIM, and outputs

10 the same as a signal S21 to the correction unit 22.

The magnification information includes an

information indicating an enlargement and/or reduction

ratio of the registered image AIM and the image to be

matched RIM. The rotation information includes an

15 information indicating a rotation angle of the registered

image AIM and the image to be matched RIM.

[0053]   In detail, for example, the magnification

information and rotation information unit 21 has a

Fourier and Mellin transform unit 211, a phase-only

20 correlation unit 212, and a magnification information and

rotation information generation unit 213.

The Fourier and Mellin transform unit 211 performs

a Fourier and Mellin transform as mentioned later to the

respective image information and outputs signals SA211

25 and SR211 indicating the respective transformed results

to the phase-only correlation unit 212.

[0054]   In detail, the Fourier and Mellin transform
unit 211 has Fourier transform units 21111 and 21112,
logarithmic transform units 21121 and 21122, and

5   logarithm-polar coordinates transform units 21131 and
21132.

[0055]   The Fourier transform unit 21111 performs
Fourier transform as expressed by the following formula
(3) to generate a Fourier image data F1(u, v) when the

10   registered image AIM is assumed as f1(m, n) in the case
where the registered image AIM is N × N pixel image, for
example, and outputs the same to the logarithmic
transform unit 21121. The Fourier transform unit 21112
performs Fourier transform as expressed by the following

15   formula (4) to generate a Fourier image data F2(u, v)
when the image to be matched RIM is assumed as f2(m, n)
in the case where the image to be matched RIM is N × N
pixel image, for example, and outputs the same to the
logarithmic transform unit 21122.

20   [0056]   The Fourier image data F1(u, v) is formed by
an amplitude spectrum A(u, v) and a phase spectrum Θ(u,
v) as expressed by the following formula (3). The Fourier
image data F2(u, v) is formed by an amplitude spectrum
B(u, v) and a phase spectrum Φ(u, v) as expressed by the

25   following formula (4).

[0057]

[Formula 3]

$$F1(u,v) = \sum_{m=0}^{N-1} \sum_{n=0}^{N-1} f1(m,n)\, e^{-j2\pi((mu+nv)/N)} = A(u,v)\, e^{j\Theta(u,v)}$$

... (3)

5   [0058]

[Formula 4]

$$F2(u,v) = \sum_{m=0}^{N-1} \sum_{n=0}^{N-1} f2(m,n)\, e^{-j2\pi((mu+nv)/N)} = B(u,v)\, e^{j\Phi(u,v)}$$

... (4)

[0059]   The logarithmic transform units 21121 and

10   21122 perform logarithmic processings to amplitude

components of the Fourier image data F1(u, v) and F2(u,

v) generated by the Fourier transform units 21111 and

21112. The logarithmic processing to the amplitude

components is carried out to emphasize a high frequency

15   component including a detail featured information of the

image data.

[0060]   In detail, the logarithmic transform unit

21121 performs the logarithmic processing to the

amplitude components A(u, v) as expressed by the

20   following formula (5) to generate A'(u, v), and outputs

the same to logarithm-polar coordinates transform unit

21131. The logarithmic transform unit 21122 performs the

logarithmic processing to the amplitude components B(u,

v) as expressed by the following formula (6) to generate
B'(u, v), and outputs the same to logarithm-polar
coordinate transform unit 21132.

[0061]

[Formula 5]

$$A'(u,v) = \log(|A(u,v)| + 1)$$

...(5)

[0062]

[Formula 6]

$$B'(u,v) = \log(|B(u,v)| + 1)$$

...(6)

[0063]   The logarithm-polar coordinates transform
units 21131 and 21132 transform the signals output from
the logarithmic transform units 21121 and 21122 to
signals of a logarithm-polar coordinates system (for
example, (log(r), Θ).

Generally, for example, when a position (x, y) is
defined such as the following formulas (7) and (8), μ is
equal to log(r) when R is equal to e^{μ}, so there is
unanimously (log(r), Θ) corresponding to any point (x,
y). The logarithm-polar coordinates transform units 21131
and 21132 perform a coordinate transform processing based
on the above nature.

[0064]

[Formula 7]

$$x = e^{\mu} \cos \Theta \qquad \qquad \ldots (7)$$

[0065]

[Formula 8]

$$y = e^{\mu} \sin \Theta \quad \left(0 \leqq \Theta \leqq 2\pi\right) \qquad \ldots (8)$$

[0066]   In detail, the logarithm-polar coordinates

transform units 21131 and 21132 define a set (r_i, θ_j)

expressed by the following formula (9) and a function

$f(r_i, \theta_j)$ expressed by the following formula (10).

[0067]

[formula 9]

$$(r_i, \theta_j) : r_i = \frac{1}{2} N^{i/N}, \quad \theta_j = \frac{2\pi j}{N} - \pi$$

$$\ldots (9)$$

[0068]

[formula 10]

$$f(r_i, \theta_j) = (r_i \cos \theta_j + N/2, \ r_i \sin \theta_j + N/2)$$

$$(i = 0, 1, \ldots, N\text{-}1, \ j = 0, 1, \ldots, N\text{-}1) \qquad \ldots (10)$$

[0069]   The logarithm-polar coordinates transform

units 21131 and 21132 perform the logarithm-polar

coordinates transform to the image data A'(u, v) and B'(u,

v) as expressed by the following formulas (11) and (12)

by applying the set (r_i, θ_j) and the function $f(r_i, \theta_j)$

defined by the formulas (9) and (10) to generate pA(r_i,

θ_j) and pB(r_i, θ_j), and output the same as the signal

SA211 and the signal SR211 to the phase-only correlation

unit 212.

[0070]

5   [formula 11]

$$pA(r_i, \theta_j) = A'(f(r_i, \theta_j))$$ ...(11)

[0071]

[formula 12]

$$pB(r_i, \theta_j) = B'(f(r_i, \theta_j))$$ ...(12)

10   [0072]   FIG. 8 is a view for explaining an operation

of the Fourier and Mellin transform unit 211 shown in FIG.

7.

     The image f1(m, n) and the image f2(m, n), for

example, include rectangle regions W1 and W2 having

15   different predetermined angles with respect to x-axis and

y-axis.

     In the Fourier and Mellin transform unit 211, for

example as shown in FIG. 8, the Fourier transform

processing is performed to the image f1(m, n) by the

20   Fourier transform units 21111 to thereby generate a

Fourier image data F1(u, v), and the image data pA(r, θ)

is generated by the logarithmic transform unit 21121 and

the logarithm-polar coordinates transform unit 21131.

[0073]   In the same way, the Fourier transform

processing is performed to the image f2(m, n) by the

Fourier transform units 21112 to thereby generate a

Fourier image data F2(u, v), and the image data pB(r, θ)

5   is generated by the logarithmic transform unit 21122 and

the logarithm-polar coordinates transform unit 21132.

[0074]   As described above, the images f1(m, n) and

f2(m, n) are transformed from Cartesian coordinates to

the logarithm-polar coordinates system (also, referred to

10   a Fourier and Mellin space) by the Fourier transform and

the logarithm-polar coordinates transform.

In the Fourier and Mellin space, there is a nature

that the component is moved along a log-r axis based on a

scaling of an image and moved along a θ-axis based on a

15   rotation angle of the image.

By applying the above nature, the scaling

(magnification information) and a rotation angle of the

images f1(m, n) and f2(m, n) may be obtained based on an

amount of the shift along the log-r axis in the Fourier

20   and Mellin space and an amount of the shift along the θ-

axis.

[0075]   The phase-only correlation unit 212, for

example, applies a phase only correlation method used in

a phase-only filter (symmetric phase-only matched filter:

25   SPOMF) to the signal SA211 and the signal SR211

respectively indicating a pattern data output from the

Fourier and Mellin transfer 211 and obtains the amount of

the parallel movement thereof.

The phase-only correlation unit 212, as shown in

5   FIG. 7, has Fourier transform units 2120 and 2121, a

combination (synthesizing) unit 2122, a phase extraction

unit 2123, and an inverse-Fourier transform unit 2124.

[0076]   The Fourier transform units 2120 and 2121

perform Fourier transform to the signals SA211 (pA(m, n))

10 and SR211 (pB(m, n)) output from the logarithm-polar

coordinates transform units 21131 and 21132 by applying

the following formulas (13) and (14). Here, X(u, v) and

Y(u, v) indicate Fourier coefficients. The Fourier

coefficient X(u, v) is formed by an amplitude spectrum

15 C(u, v) and a phase spectrum θ(u, v) as expressed by the

following formula (13). The Fourier coefficient Y(u, v)

is formed by an amplitude spectrum D(u, v) and a phase

spectrum φ(u, v) as expressed by the following formula

(14).

20 [0077]

[formula 13]

$$X(u,v) = \sum_{m=0}^{N-1} \sum_{n=0}^{N-1} pA(m,n)\, e^{-j2\pi((mu+nv)/N)} = C(u,v)\, e^{j\theta(u,v)}$$

...(13)

[0078]

[formula 14]

$$Y(u,v) = \sum_{m=0}^{N-1} \sum_{n=0}^{N-1} pB(m,n)\, e^{-j2\pi((mu+nv)/N)} = D(u,v)\, e^{j\phi(u,v)}$$

$$\ldots (14)$$

[0079]   The combination unit 2122 combines $X(u, v)$ and $Y(u, v)$ generated by the Fourier transform units 2120 and 2121, and obtains the correlation. For example, the combination unit 2122 generates $X(u, v) \cdot Y^*(u, v)$ and outputs the same to the phase extraction unit 2123. Here, $Y^*(u, v)$ is defined as a complex conjugate of $Y(u, v)$.

[0080]   The phase extraction unit 2123 deletes an amplitude component based on a combined signal output from the combination unit 2122 and extracts a phase information.

For example, the phase extraction unit 2123 extracts the phase component which is $Z(u, v) = e^{j(\theta(u, v) - \phi(u, v))}$ based on the $X(u, v)Y^*(u, v)$.

[0081]   The extraction of the phase information is not limited to the above. For example, based on the output from the Fourier transform units 2120 and 2121 and the following formulas (15) and (16), the phase information is extracted and only the phase components are combined as expressed by the following formula (17) to generate $Z(u, v)$.

[0082]

[formula 15]

$$X'(u,v) = e^{j\theta(u,v)} \qquad \ldots (15)$$

[0083]

[formula 16]

$$Y'(u,v) = e^{j\phi(u,v)} \qquad \ldots (16)$$

[0084]

[formula 17]

$$Z(u,v) = X'(u,v)(Y'(u,v))^* = e^{j(\theta(u,v)-\phi(u,v))}$$

$$\ldots (17)$$

[0085]   The inverse-Fourier transform unit 2124 performs the inverse-Fourier transform processing to the signal Z(u, v) including the only phase information and output from the phase extraction unit 2123 to generate a correlation intensity image.

In detail, the inverse-Fourier transform unit 2124 performs the inverse-Fourier transform processing on the signal Z(u, v) as expressed by the following formula (18) to generate a correlation intensity image G(p, q).

[0086]

[formula 18]

$$G(p,q) = \sum_{u=0}^{N-1}\sum_{v=0}^{N-1}(Z(u,v))\,e^{j2\pi((up+vq)/N)} = \sum_{u=0}^{N-1}\sum_{v=0}^{N-1}(e^{j(\theta(u,v)-\phi(u,v))})\,e^{j2\pi((up+vq)/N)}$$

...(18)

[0087]   The magnification information and rotation

information generation unit 213 generates a correction

information S21 including a data indicating a

5   magnification information (enlargement and/or reduction

ratio) and a rotation angle information of the image to

be matched RIM to the registered image AIM by detecting

the amount of shift between an image center and a peak

position in the correlation intensity image G(p, q)

10   generated by the inverse-Fourier transform unit 2124. The

amount of the shift is equal to the amount of the

parallel shift between the registered image AIM and a

pattern data obtained by performing the Fourier-Mellin

transform to the image to be matched RIM.

15   [0088]   The correction unit 22 corrects the image to

be matched RIM based on the correction information S21

output from the magnification information and rotation

information generation unit 213 in the magnification

information and rotation information unit 21. In detail,

20   the correction unit 22 performs an enlargement and/or

reduction processing and a rotation processing to the

image to be matched RIM based on a magnification

information and the rotation angle information included

in the correction information S21, and outputs the result

25   to the phase-only correlation unit 23. By the correction

processing of the correction unit 22, a scaling

difference and a rotation component difference between

the registered image AIM and the image to be matched RIM

are deleted.

5   Therefore, only a parallel movement component

remains as the difference between the registered image

AIM and the image to be matched RIM to which the

correction processing was performed.

[0089]   The phase-only correlation unit 23 detects

10   the parallel movement component between the registered

image AIM and the image to be matched RIM to which the

correction processing was performed, and also detects the

correlation value thereof. The detection processing, for

example, is performed by applying the phase-only

15   correlation method used in the phase-only filter

described above.

In detail, the phase-only correlation unit 23 has

Fourier transform units 2311 and 2312, a combination unit

232, a phase extraction unit 233, and an inverse-Fourier

20   transform unit 234.

[0090]   The Fourier transform units 2311 and 2312,

the combination unit 232, the phase extraction unit 233,

and the inverse-Fourier transform unit 234 have

respectively the same functions as the Fourier transform

25   units 2120 and 2121, the combination unit 2122, the phase

extraction unit 2133, and the inverse-Fourier transform unit 2124 of the phase-only correlation unit 212 and explanations will be simplified.

[0091]   The Fourier transform unit 2311 performs the

5   Fourier transform processing to the registered image AIM, and outputs the result to the combination unit 232. In the above case, the registered image AIM to which the Fourier transform processing was performed by the Fourier transform unit 21111 may be stored in the memory 12, and

10   output to the combination unit 232. Consequently, the Fourier transform is not performed two times, so the processing is reduced.

The Fourier transform units 2312 performs the Fourier transform processing to the image S22 corrected

15   by the correction unit 22, and outputs the result of a Fourier image to the combination unit 232.

[0092]   The combination unit 232 combines the Fourier images S2311 and S2312 output from the Fourier transform units 2311 and 2312, and outputs the combined image S232

20   to the phase extraction unit 233.

The phase extraction unit 233 extracts the phase information based on the combined image S232 as described above, and outputs a signal S233 to the inverse-Fourier transform unit 234.

25   The inverse-Fourier transform unit 234 performs the

inverse-Fourier transform processing to the signal S233
to thereby generate a correlation intensity image
(correlation image data), and outputs the same as a
signal S23 to the shift information generation unit 24.

[0093]   A processing for detecting the amount of the
parallel movement in the above phase-only correlation
method will be described in detail.

For example, the Fourier transform processing is
performed to the original image f1(m, n), the original
image f2(m, n), and an image f3(m, n) = f2(m+α, n+β) in
which the image f2(m, n) is moved in parallel, to thereby
generate Fourier coefficients F1(u, v), F2(u, v), and
F3(u, v) as expressed by the following formulas (19) to
(21).

[0094]

[formula 19]

$$F1(u,v) = \sum_{m=0}^{N-1} \sum_{n=0}^{N-1} f1(m,n)\, e^{-j2\pi((mu+nv)/N)} = A(u,v)\, e^{j\Theta(u,v)}$$

$$\dots (19)$$

[0095]

[formula 20]

$$F2(u,v) = \sum_{m=0}^{N-1} \sum_{n=0}^{N-1} f2(m,n)\, e^{-j2\pi((mu+nv)/N)} = B(u,v)\, e^{j\Phi(u,v)}$$

$$\dots (20)$$

[0096]

[formula 21]

$$F3(u,v) = \sum_{m=0}^{N-1} \sum_{n=0}^{N-1} f2(m+\alpha, n+\beta)\, e^{-j2\pi((mu+nv)/N)} = B(u,v)\, e^{j(\Phi(u,v)+2\pi(\alpha u+\beta v)/N)}$$

...(21)

[0097]   Based on the Fourier coefficients F1(u, v) to

F3(u, v), phase images F'1(u, v) to F'3(u, v) including

only the phase information are generated as expressed by

the following formulas (22) to (24).

[0098]

[formula 22]

$$F'1(u,v) = e^{j\Theta(u,v)}$$

...(22)

[0099]

[formula 23]

$$F'2(u,v) = e^{j\Phi(u,v)}$$

...(23)

[0100]

[formula 24]

$$F'3(u,v) = e^{j(\Phi(u,v)+2\pi(\alpha u+\beta v)/N)}$$

...(24)

[0101]   A phase image correlation Z12(u, v) as the

correlation between the phase image F'1(u, v) and the

phase image F'2(u, v) is calculated as expressed by the

following formula (25). A phase image correlation Z13(u,

v) as the correlation between the phase image F'1(u, v)

and the phase image F'3(u, v) is calculated as expressed by the following formula (26).

[0102]

[formula 25]

$$Z12(u,v) = F'1(u,v)(F'2(u,v))^* = e^{j(\Theta(u,v) - \Phi(u,v))}$$

$$\ldots (25)$$

[0103]

[formula 26]

$$Z13(u,v) = F'1(u,v)(F'3(u,v))^* = e^{j(\Theta(u,v) - \Phi(u,v) - 2\pi(\alpha u + \beta v)/N)}$$

$$\ldots (26)$$

[0104]   A correlation intensity image G12(r, s) of the correlation Z12(u, v) and a correlation intensity image G13(r, s) of the correlation Z13(u, v) are calculated as expressed by the following formulas (27) and (28).

[0105]

[formula 27]

$$G12(r,s) = \sum_{u=0}^{N-1} \sum_{v=0}^{N-1} (Z12(u,v)) \, e^{j2\pi((ur+vs)/N)} = \sum_{u=0}^{N-1} \sum_{v=0}^{N-1} (e^{j(\Theta(u,v) - \Phi(u,v))}) \, e^{j2\pi((ur+vs)/N)}$$

$$\ldots (27)$$

[0106]

[formula 28]

$$G13(r,s) = \sum_{u=0}^{N-1} \sum_{v=0}^{N-1} (Z13(u,v))\, e^{j2\pi((ur+vs)/N)}$$

$$= \sum_{u=0}^{N-1} \sum_{v=0}^{N-1} (e^{j(\Theta(u,v)-\Phi(u,v)-2\pi(\alpha u+\beta v)/N)})\, e^{j2\pi((ur+vs)/N)}$$

$$= G12(r-\alpha, s-\beta)$$

$$\ldots (28)$$

[0107]   As expressed by the above formulas (27) and (28), in the case where the image f3(m, n) is shifted to (+α, +β) in comparison with the image 2(m, n), a correlation intensity peak is generated at a position shifted to (-α, -β) in the correlation intensity image in the phase-only correlation method. The amount of the parallel movement between the two images can be obtained based on the position of the correlation intensity position.

Further, by applying the phase-only correlation method in the Fourier and Mellin space, the amount of the parallel movement in the Fourier and Mellin space can be detected. The amount of the parallel movement, as described above, corresponds to the magnification information and the rotation angle information in a real space.

[0108]   FIGs. 9A to 9F are views for explaining different points between the self correlation method and the phase-only correlation method.

In the self correlation method, as shown in FIGs. 9A and 9B, the Fourier transform is performed to an image IM1 and an image IM2 the same as the image IM1 to thereby generate a self correlation function SG1. As shown in FIG.

5   9C, correlation intensity distributions including a high correlation intensity peak and a low correlation intensity peak around it, are obtained. In FIG. 9C, an ordinate (z-axis) indicates the correlation intensity, and an x-axis and a y-axis indicate the amount of the

10   shift.

[0109]   Otherwise, in the phase-only correlation method described above, as shown in FIGs. 9D and 9E, the Fourier transform is performed to the image IM1 and the image IM2 the same as the image IM1, and only the phase

15   information is correlated, as a result, correlation distributions including only a high and sharp correlation intensity peak are obtained as shown in FIG. 9F. In this way, the performance of the phase-only method can obtain a precise information concerning the correlation in

20   comparison with the self correlation method. In FIG. 9F, an ordinate (z-axis) indicates the correlation intensity, and an x-axis and a y-axis indicate the amounts of the shifts.

[0110]   FIGs. 10A to 10C are views for explaining the

25   correlation intensity distributions in the case where the

parallel movement shift exists between two images, in the phase-only correlation method.

For example, in the correlation intensity distributions by applying the phase-only method to the image IM1 and an image IM3 in which a plurality of pixels are moved in parallel from the image IM1, shown in FIGs. 10A and 10B, a high and sharp correlation intensity peak is distributed at a position shifted from a peak position with a distance depending on the amount of the parallel movement in a correlation image data as shown in FIG. 9F. However, the peak intensity shown in FIG. 10C is smaller than that shown in FIG. 9F. This is because pixel regions where the images IM1 and IM3 are matched are smaller than that of the images IM1 and IM2.

[0111]   FIGs. 11A to 11C are views for explaining the correlation intensity distributions in the case where the rotation shift exists between two images, in the phase-only correlation method.

In the correlation intensity distributions by applying the phase-only method to the image IM1 and an image IM4 rotating several degrees from the image IM1, shown in FIG. 11A and 11B, for example, a weak correlation intensity distribution is obtained as shown in FIG. 11C. In the case where the phase-only correlation method is simply applied, it is difficult to detect the

correlation due to the rotation shift.

[0112]   Therefore, in the image matching apparatus 1a according to the present embodiment, the Fourier and Mellin transform is performed to the registered image AIM and the image to be matched RIM, the amount of the parallel movement is detected in the Fourier and Mellin space by applying the phase-only correlation method, and the magnification information and the rotation angle information of the registered image AIM and the image to be matched RIM are detected. The magnification and the rotation angle of the image to be matched are corrected based on the above information.

The parallel movement shift between the corrected image to be matched RIM and the registered image AIM is detected by applying the phase-only correlation method, and simultaneously, the matching of the images are performed based on the correlation peak.

[0113]   FIGs. 12A to 12C are views for explaining a correlation image data output by the phase-only correlation unit 23. FIG. 12A shows an example of the registered image AIM, FIG. 12B shows an example of the image to be matched RIM, and FIG. 12C shows a specific example of the correlation image data. FIG. 13 is a view for explaining the correlation image data shown in FIG. 12C.

[0114]   In the case where a binary pattern and a

linear shaped pattern of a hand-written character or a

blood vessel pattern are included in the registered image

AIM and the image to be matched RIM, for example, in the

5   case of the registered image AIM and the image to be

matched RIM shown in FIGs. 12A and 12B, the phase-only

correlation unit 23 outputs a correlation image data

shown in FIG. 12C as the signal S23.

[0115]   In FIG. 12C, a z-axis direction indicates a

10   correlation peak intensity in the correlation image data,

and the correlation peak intensity corresponds to the

degree of the correlation between the registered image

AIM and the image to be matched RIM. As shown in FIG. 12C

and FIG. 13, in a correlation peak position PP in a x-

15   axis direction and a y-axis direction, for example, the

amount of the shift from a image center corresponds to

the amount of the parallel movement between the

registered image AIM and the image to be matched RIM.

[0116]   The shift information generation unit 24

20   generates the amount of the shift from the image center

as a shift information based on the signal S23 output

from the phase-only correlation unit 23, and outputs a

signal S24 to the correction unit 25.

[0117]   The correction unit 25 performs a position

25   correction processing to the image to be matched RIM

based on the image to be matched RIM and the signal S24

as the shift information output from the shift

information generation unit 24, and outputs the resultant

as a signal S1612.

5   [0118]   FIG. 14 is a flow chart for explaining an

operation of the image matching apparatus 1 shown in FIG.

1. The operation of the image matching apparatus 1a

having the configuration described above will be

described with reference to FIG. 14 in terms of a

10   different point from the first embodiment.

[0119]   For example, the registered image AIM and the

image to be matched RIM are input from the image input

unit 11, and the respective image data are stored in the

memory (ST1).

15   Here, in order to obtain the magnifications

(enlargement and/or reduction ratio) and the rotation

angle information of the image to be matched RIM to the

registered image AIM, the registered image AIM is read

out from the memory 12 (ST2), and applied with the

20   Fourier transform processing in the Fourier transform

unit 21111 in the magnification information and rotation

information unit 21 (ST3), and a generated Fourier image

data S21111 is stored or recorded in the memory 12 (ST4).

        An amplitude component in the Fourier image data

25   S21111 is applied with the logarithmic processing by the

logarithmic transform unit 21121, and transformed to a

logarithm-polar coordinates system by the logarithm-polar

coordinates transform unit 21131 (ST5).

[0120]   The image to be matched RIM is read out from

5   the memory 12 (ST6), and applied with the Fourier

transform by the Fourier transform unit 21112 in the same

way (ST7). The amplitude component in the Fourier image

data S21112 is applied with the logarithmic processing by

the logarithmic transform unit 21122, and transformed to

10   a logarithm-polar coordinates system by the logarithm-

polar coordinates transform unit 21132 (ST8).

[0121]   Image signals (also, referred to pattern

data) SA211 and SR211, obtained by performing the Fourier

and Mellin transform to the above registered image AIM

15   and the image to be matched RIM, are respectively applied

with the Fourier transform processing by the Fourier

transform units 2120 and 2121 of the phase-only

correlation unit 212 (ST9), and combined by the

combination unit 2122 (ST10). The amplitude component is

20   deleted from the combined signal by the phase extraction

unit 2123 (ST11), the residual phase component is applied

with the inverse-Fourier transform processing by the

inverse-Fourier transform unit 2124 (ST12), and a

correlation information including the magnification

25   information and the rotation information is generated

(detected) by the magnification information and rotation

information generation unit 213, based on the amount of

the shift between the image center and the peak position

of the obtained correlation image data (ST13).

5   [0122]   The correction unit 22 performs the

correction processing for enlargement and/or reduction

and the rotation processing to the image to be matched

based on the correction information to thereby delete the

scaling component and the rotation component between the

10   images (ST14). The residual difference is only the

parallel movement component, which is detected by

applying the phase-only correlation method.

[0123]   The image to be matched RIM to which the

correction processing was performed, is applied with the

15   Fourier transform by the Fourier transform unit 2312 of

the phase-only correlation unit 23 (ST15) to thereby

generate a Fourier image data S2312, the registered image

AIM stored in the memory 12 and applied with the Fourier

transform processing, is read out (ST16), and a combined

20   data S232 is generated by the combination unit 232 (ST17).

[0124]   In the above case, the registered image AIM

may be applied with the Fourier transform processing in

the Fourier transform unit 2311 to thereby generate the

Fourier image data S2311, and output the same to the

25   combination unit 232.

The amplitude information in the combined data S232 is deleted by the phase extraction unit 233 (ST18), the residual phase information is input to the inverse-Fourier transform unit 234, and a signal S23 is output as

5   the correlation image data (ST19).

Based on the signal 23, the amount of the shift of the peak position is detected by the shift information generation unit 24, and the signal S24 is output as the shift information (ST20).

10   In the correction unit 25, the position correction processing is performed to the registered image AIM and the image to be matched RIM based on the signal S24 as the shift information and the image to be matched RIM, then a signal S1612 is output. Also, the registered image

15 AIM is output as a signal S1611 (ST21).

[0125]   The following operations are the substantially same as the first embodiment, the Hough transform unit 162 performs the Hough transform processing (ST22), the extraction unit 163 performs the

20 extraction processing (ST23), and the similarity generation unit 1641 generates the similarity Sim (ST24).

At step ST25, the matching unit 1642 judges whether or not the similarity Sim is larger than (or exceeds) the threshold set in advance. If it is larger than the

25 threshold, it is judged that the registered image AIM and

the image to be matched RIM are matched (ST26), otherwise,
if it is smaller than the threshold, it is judged that
they are mismatched (ST27).

As described above, in the present embodiment, the
position correction unit 161, as the position correction
processing, generates the correlation value based on the
phase components which are results of the rotation angle
correction processing or the magnification ratio
correction processing and the Fourier transform
processing to the registered image AIM and the image to
be matched RIM, and performs the position correction
processing to the registered image AIM and the image to
be matched RIM based on the generated correlation value,
consequently, the position correction processing can be
performed at a high accuracy, as a result, the matching
processing can be performed at a high accuracy.

[0127]   FIG. 15 is a functional block diagram of an
image matching apparatus of a third embodiment according
to the present invention.

An image matching apparatus 1b according to the
present embodiment, in the functional block diagram
illustrated as a hardware, has the approximately same
configuration as the image matching apparatus 1 according
to the first embodiment, and, for example, has the image
input unit 11, the memory 12, the FFT processing unit 13,

the coordinate transform unit 14, the Hough transform

unit 15, the CPU 16, and the operation processing unit 17

as shown in FIG. 1.

The image matching apparatus 1b, in the functional

5   block diagram illustrated as a software, has the

approximately same configuration as the image matching

apparatus 1 according to the second embodiment, and the

CPU 16 executes the program PRG to realize functions of a

position correction unit 161b, the Hough transform unit

10   162, the extraction unit 163, and a judgment unit 164b.

In FIG, 15, components the same as those of the above

embodiments are assigned the same notations and

explanations thereof are omitted. And only different

points will be described.

15   [0128]   A large different point is the following: the

position correction unit 161b and the judgment unit 164b

being different.

In the present embodiment, the position correction

unit 161b performs the correlation processing to the

20   registered image AIM and the image to be matched RIM to

generate a plurality of the correlation value indicating

the correction position, and performs a plurality of the

position correction processing to the registered image

AIM and the image to be matched RIM based on the

25   generated correlation value.

[0129]   FIGs. 16A and 16B are views for explaining an

operation of the position correction unit shown in FIG.

15. Numerical values indicate the correlation peak

intensities of the correlation image data in the x-y

5 plane.

        For example, in the case where the registered image

AIM and the image to be matched RIM include the binary

linear component (linear shape) pattern, the correlation

peak intensity (also, referred to a correlation

10 intensity) is small value as shown in FIGs. 16A and 16B

even if the correlation of the images is large.

        For example, based on the signal S23, the shift

information generation unit 24 of the position correction

unit 161b specifies N number of the correlation

15 intensities successively from the top as shown in FIG.

16A, for example, 8 of the correlation value and the

correlation peak positions in the present embodiment, as

an object of a positional relationship between the

registered image AIM and the image to be matched RIM on a

20 two-dimension.

        The position correction unit 161b performs the

plurality of the position correction processing if

necessary, to a plurality of the correlation values and

the position of the correlation peaks corresponding to

25 the above values.

[0130]   The Hough transform unit 162 performs the

Hough transform processing to the registered image AIM

and the image to be matched RIM which are results of the

plurality of the position correction processing to

5   thereby generate the transformed images S1621 and S1622.

The judgment unit 164b generates the correlation

value based on patterns in the two transformed images,

and performs the matching processing to the registered

image AIM and the image to be matched RIM based on the

10   generated correlation value and the threshold set in

advance. The judgment unit 164b performs the matching

processing to the result of the plurality of the position

correction processing based on the total amount of the

correlation value corresponding to different positions

15   and the threshold set in advance.

[0131]   In detail, the judgment unit 164b has the

similarity generation unit 1641, a matching unit 1642b,

and the accumulation unit 1643.

The similarity generation unit 1641, for example,

20   generates the similarity Sim by applying the above

formula (2) based on the signals S1631 and S1632 as

described above, and outputs the same as a signal S1641

to the accumulation unit 1643 and the matching unit 1642b.

[0132]   The accumulation unit 1643 accumulates the

25   similarity Sim based on the signal S1641, and outputs the

accumulated result as a signal S1643 to the matching unit

1642b.

The matching unit 1642b performs the matching of

the image to be matched RIM and the registered image AIM

5   based on the signal S1641 and the signal S1643.

The different point from the matching unit 1642

according to the first embodiment is the followings: the

matching unit 1642b judging that the registered image AIM

and the image to be matched RIM are matched when the

10   signal S1643 as the accumulation value of the similarity

Sim generated by the accumulation unit is larger than the

predetermined threshold.

[0133]   FIG. 17 is a flow chart for explaining an

operation of the image matching apparatus of the third

15   embodiment according to the present embodiment. While

referring to the FIG. 14 and FIG. 17, the operation of

the image matching apparatus, mainly the operation of the

CPU 16, will be described in terms of the different

points from the first embodiment and the second

20   embodiment.

[0134]   Steps ST1 to ST19 are the same operations as

the second embodiment shown in FIG. 14 and explanations

will be omitted.

Based on the correlation image data S23 output from

25   the phase-only correlation unit 23 at step ST19, N number

of objects P_i (P_0, P_1, P_2, ..., P_{n-1}) are extracted

successively from the upper side of the correlation peak

intensity in the correlation image data S23 by the shift

information generation unit 24 (ST28).

5   [0135]   At step ST29, the accumulation unit 1643

initializes variables for accumulation. For example, the

variable i is initialized to 0 and the accumulation value

S is initialized to 0.

       The correction unit 25 performs the position

10   correction processing to the registered image AIM and the

image to be matched RIM based on the respective objects

(coordinates) P_i and the amount of the shift

corresponding to the object from the center position and

the correlation image data (ST30).

15   [0136]   As described above, the Hough transform

processing is performed to the registered image AIM and

the image to be matched RIM by the Hough transform unit

162 (ST31), the extraction processing is performed by the

extraction unit 163 (ST32), and the similarity Sim(i) is

20   calculated by the similarity generation unit 1641 and

output to the accumulation unit 1643 and the matching

unit 1642b (ST33).

       [0137]   The matching unit 1642b compares the

similarity Sim(i) with a first threshold th1 set in

25   advance. In the case where the similarity Sim(i) is

smaller than the first threshold (ST34), the accumulation

unit 1643 accumulates the similarity Sim(i), in detail,

accumulates the same by formula S = S + Sim(i) and

outputs the result to the matching unit 1642b (ST35).

5   At step ST35, the matching unit 1642b compares the

accumulation value S with a second threshold th2 set in

advance (ST36), the variable i and a value N-1 are

compared in the case where the accumulation value S is

smaller than the second threshold th2 (ST27), the

10 variable i is added with one in the case where the

variable i dose not matched N-1 (ST28), and the routine

returns to step ST30. At step ST27, in the case where the

variable i matches N-1, the images are mismatched (ST39).

[0138]   On the other hand, in the comparison

15 processing at step ST34, the matching unit 1642b judges

that the images are matched in the case where the

similarity Sim(i) is equal to or larger than the first

threshold. In the comparison processing at step ST36, the

matching unit 1642b judges that the images are matched in

20 the case where the accumulated value S is equal to or

larger than the second threshold th2 (ST40). For example,

in the case where the image matching apparatus according

to the present embodiment is applied to a vein pattern

matching apparatus in a security field, the operation

25 processing unit 17 performs a processing such that the

electric key is released.

[0139]   As described above, in the present embodiment, the position correction unit 161 generates a plurality of the correlation value indicating the positions to be

5   corrected, performs the plurality of the position correction processing to the registered image AIM and the image to be matched RIM based on the generated correlation value. The Hough transform unit 162 performs the Hough transform processing as an image processing to

10   the registered image AIM and the image to be matched RIM which are results of the plurality of the position correction processings. And the matching unit 1642b performs the matching processing to the accumulation value of the similarity as the correlation value

15   corresponding to the pattern in each of the transformed images. Consequently, for example even if the correlation between the two image data to be compared is small, the similarity calculated in the respective positional relationships in the objects are accumulated, so the

20   matching can be performed at a high accuracy in comparison with the case where the matching is performed by applying only the similarity.

[0140]   When the similarity Sim is larger than the first threshold th1, the matching unit judges that the

25   two images are matched, so the matching processing can be

performed at high speed.

[0141]   FIG. 18 is a functional block diagram of an

image matching apparatus of a fourth embodiment according

to the present invention.

5   An image matching apparatus 1c according to the

present embodiment, in the functional block diagram

illustrated in a hardware, has the approximately same

configuration as the image matching apparatus 1 according

to the above embodiment, and, for example, has the image

10   input unit 11, the memory 12, the FFT processing unit 13,

the coordinate transform unit 14, the Hough transform

unit 15, the CPU 16, and the operation processing unit 17

as shown in FIG. 1.

The image matching apparatus 1c, in the functional

15   block diagram illustrated in a software, has the

approximately same configuration as the image matching

apparatus according to the above described embodiments,

and the CPU 16 executes the program PRG to realize

functions of the position correction unit 161, the Hough

20   transform unit 162, an extraction unit 163c, and the

judgment unit 164. In FIG, 18, components the same as

those of the above embodiments are assigned the same

notations and explanations thereof are omitted. And only

different point will be described.

25   [0142]   A large different point is the following: the

extraction unit 163c being different.

In the present embodiment, the extraction unit 163c extracts regions where the degree of the overlap of the curved patterns in the transformed image is equal to or

5   greater than the threshold set in advance, from the first transformed image and the second transformed image, and determines the threshold based on a size of the extracted region such that the size of the extracted region is larger than the set value.

10   The extraction unit 163c determines the threshold based on the size of the extracted region such that the size of the extracted region is within the set range.

[0043]   FIGs. 19A to 19F are views for explaining an operation of the image matching apparatus 1c shown in FIG.

15   17.

FIG. 19A is a view showing a specific example of an image IM11. FIG. 19B is a view showing an image in which a region equal to or greater than the first threshold is extracted from the image IM11 shown in FIG. 19A. FIG. 19C

20   is a view showing an image in which a region equal to or greater than a second threshold larger than the first threshold is extracted from the image IM11 shown in FIG. 19A.

FIG. 19D is a view showing a specific example of an

25   image IM12. FIG. 19E is a view showing an image in which

a region equal to or greater than the first threshold is

extracted from the image IM12 shown in FIG. 19D. FIG. 19F

is a view showing an image in which a region equal to or

greater than a second threshold larger than the first

5   threshold is extracted from the image IM12 shown in FIG.

19D.

[0144]   For example, in the above described

embodiments, when performing the Hough transform

processing to the registered image and the image to be

10   matched prior to extracting the amount of features

(parameter) from the transformed image, since the

threshold is fixed, the sufficient amount of features may

not be extracted or the redundant amount of the features

may be extracted depending on the images.

15   [0145]   In detail, when performing the Hough

transform processing to the image IM11 shown in FIG. 19A

before extracting the region larger than the first

threshold from the transform image, an image IM111 shown

in FIG. 19B is generated, otherwise, when extracting the

20   region larger than the second threshold, an image IM112

shown in FIG. 19C is generated.

[0146]   When performing the Hough transform

processing to the image IM12 shown in FIG. 19D prior to

extracting the region larger than the first threshold

25   from the transform image, an image IM121 shown in FIG.

19E is generated, otherwise, when extracting the region

larger than the second threshold, an image IM122 shown in

FIG. 19F is generated.

[0147]   For example, the images IM112 and IM121 are

5   specific examples including the amount of the data

(features) appropriate to the matching processing.

        The image IM111 is a specific example including the

amount of the data (features) redundant to the matching

processing.

10   The image IM122 is a specific example extracted

with the amount of data (features) insufficiently to the

matching processing.

[0148]   In the case of where the threshold is fixed,

for example, the comparison and matching processing is

15   performed to the image IM111 and the image IM121 or the

image IM112 and the image IM122, so judgment accuracy may

sometimes be insufficient.

        For example, while changing the threshold, the

comparison and matching processing are performed to the

20   image IM112 and the image IM121 including the amount of

data (features) sufficiently to the matching processing,

so the judgment accuracy is improved.

[0149]   Therefore, the extraction unit 163c according

to the present embodiment, in the case where the amount

25   of features extracted by applying a certain threshold is

the out of the suitable range for the matching when

extracting the amount of features to the transformed

image to which the Hough transformed processing was

performed, changes the threshold and extracts the amount

5   of the features again, and determines the amount of

feature so as to be within the suitable range.

[0150]   FIG. 20 is a flow chart for explaining an

operation of the image matching apparatus according to

the present embodiment. While referring to FIG. 20, the

10   operation of the image matching apparatus, mainly a

different point from the embodiment shown in FIG. 14,

will be described.

[0151]   The operations of steps ST1 to ST22 are the

same and explanations will be omitted.

15   At step ST231, the extraction unit 163c extracts a

parameter portion exceeding the threshold set in advance

from the respective transformed images S1612 and S1622

generated by the Hough transform unit 162, as the amount

of features.

20   [0152]   The extraction unit 163c determines the

threshold based on the size of the extracted region such

that the size of the extracted region is within the set

range.

In detail, the extraction unit 163c determines the

25   threshold such that the size of the extracted region is

larger than the minimum value <u>min</u> based on the size of

the extracted region, also determines the same such that

the size of the extracted region is smaller than the

maximum value <u>max</u> larger than the minimum value <u>min</u>.

5   [0153]   For example, at step ST232, the extraction

unit 163c judges whether or not the size of the region

extracted as the amount of features is larger than the

minimum value <u>min</u>, and reduces the threshold at a

predetermined amount if it judges it is not larger

10   (ST233), the routine retunes to step ST321.

        Otherwise, at step ST232, the extraction unit 163c

judges that the size of the region extracted as the

amount of features is larger than the minimum value <u>min</u>,

the routine proceeds to step ST234.

15   [0154]   At step ST234, the extraction unit 163c

judges whether or not the size of the region extracted as

the amount of the features is smaller than the maximum

value <u>max</u>, and increases the threshold at the

predetermined amount if it judges it is not smaller

20   (ST233), the routine returns to step ST231.

        Otherwise, at step ST234, the extraction unit 163c

judges that the size of the region extracted as the

amount of the features is smaller than the maximum value

<u>max</u>, the routine proceeds to step ST24.

25   [0155]   The following steps of step ST24 are the same

as the processing shown in FIG. 14 and explanations will

be omitted.

[0156]   As described above, the extraction unit 163c

determines the threshold such that the size of the

5   extracted region is within the set range based on the

size of the extracted region, so data redundant to the

matching processing can be reduced and data suitable for

the matching processing can be extracted.

The image appropriate for the matching processing

10 can be obtained, so the matching unit 164 can perform the

matching processing at a high accuracy.

In the case where an imaging system increasingly

changes and the amount of data of the input image sharply

changes, the comparison and matching processing can be

15 performed without any change.

[0157]   FIG. 21 is a flow chart for explaining an

operation of an image matching apparatus of a fifth

embodiment according to the present invention.

The image matching apparatus according to the

20 present embodiment, in the functional block diagram

illustrated in a hardware, has the approximately same

configuration as the image matching apparatus according

to the above embodiments, and, for example, has the image

input unit 11, the memory 12, the FFT processing unit 13,

25 the coordinate transform unit 14, the Hough transform

unit 15, the CPU 16, and the operation processing unit 17

as shown in FIG. 1.

[0158]   For example, in the case where the amount of

features of the registered image and the image to be

5   matched is remarkably few, the amount of the features

insufficient to the comparison and matching processing

may be obtained, so an insufficient judgment accuracy may

be obtained.

The image matching apparatus according to the

10   present embodiment extracts the region where the degree

of the overlap of the curved patterns in the transformed

image is equal to or greater than the threshold set in

advance, the image is deleted in the case where the size

of the extracted region is smaller than the set value.

15   [0159]   While referring to FIG. 21, mainly a

different point from the above embodiments in the case

where a certain image data is stored as the registered

image for matching will be described, for example, in an

application of a personal matching apparatus applied with

20   a blood vessel pattern.

[0160]   At step ST101, the CPU 16 causes the image

input unit 11 to capture an image data to be stored as

the registered image AIM, and stores the image data in

the memory 12. The CPU 16 causes the Hough transform unit

25   15 to perform the Hough transform processing to the

captured image data (ST102).

[0161]   At step ST103, the CPU 16 extracts a region

exceeding the threshold set in advance as the amount of

the features (ST103).

5   At step ST104, the CPU 16 judges whether or not the

size of the extracted region is larger than the minimum

value min which is minimum necessary for the matching

processing, decides that the amount of the information

sufficiently to the registered image AIM is included if

10   it is judged to be larger, and stores the image data in

the memory 12 (ST105).

[0162]   Otherwise, at step ST104, if it is judged not

to be larger than the minimum value min, the input image

is deleted (ST106), and a re-input of the image data is

15   requested, for example, by displaying a notice that the

amount of the information as the registered image AIM is

insufficiency (ST107). Then, the above described matching

processing is performed.

[0163]   In the present embodiment as described above,

20   in registering an image, the region where the degree of

the overlap of the curved patterns in the transformed

image to be registered is equal to or greater than the

threshold set in advance is extracted, then the image is

deleted in the case where the size of the extracted

25   region is less than the set value (the minimum value min),

so the image to be registered having relatively large

amount of the features concerning the matching apparatus

can be obtained steadily. And the matching processing can

be performed at a high accuracy.

5   [0164]   FIG. 22 is a flow chart for explaining an

operation of an image matching apparatus of a sixth

embodiment according to the present embodiment.

The case where the image to be matched RIM input

from an external is matched with the registered image AIM

10   stored in the memory 12 in advance, will be described

with reference to FIG. 22.

[0165]   At step ST201, the CPU 16 causes the image

input unit 11 to capture the image data as the image to

be matched RIM, and stores the image data in the memory

15   12. The CPU 16 causes the Hough transform unit 15 to

perform the Hough transform processing to the captured

image to be matched (ST202).

[0166]   At step ST203, the CPU 16 extracts the region

exceeding the threshold set in advance as the amount of

20   the features (ST203).

At step ST204, the CPU 16 judges whether or not the

size of the extracted region is larger than the minimum

value min which is minimum necessary for the matching

processing, decides that the amount of the information is

25   no sufficient to the image to be matched RIM if it is

judged not to be larger, deletes the image (ST205),

requests the re-input of the image data, for example, by

displaying a notice that the amount of the information is

not sufficient (ST206), and terminates the matching

5   processing.

[0167]   Otherwise, in the judgment at step ST204, if

it is judged to be larger than the minimum value min, the

CPU 16 judges that the amount of information is

sufficient to the image to be matched RIM, the routine

10   proceeds to the following matching processing of steps

ST2 to ST27.

[0168]   The following operations of steps ST2 to ST27

are the same as the operation shown in FIG. 14 and

explanations will be omitted.

15   [0169]   As described above, in the present embodiment,

in matching images, the region where the degree of the

overlap of the curved patterns in the transformed image

to be matched is equal to or greater than the threshold

set in advance, is extracted, and the image is deleted in

20   the case where the size of the extracted region is less

than the set value (the minimum value min), so the image

to be matched including relatively large amount of the

features applied to the matching apparatus can be

obtained steadily. And the matching processing can be

25   performed at a high accuracy.

[0170]   Note that, the present invention is not

limited to the present embodiments and it can be modified

in various ways.

For example, in the present embodiment, though the

5   similarity generation unit calculates the similarity by

applying the formula (2), it is not limited thereto. For

example, the similarity generation unit may perform a

processing in which the similarity suitable to the

correlation of the linear components (linear shaped

10   patterns) is calculated.

[0171]   In the present embodiment, though the Fourier

transform processing, the logarithmic transform

processing, and a logarithm-polar coordinates transform

processing are performed and the amount of parallel

15   movement on the Fourier and Mellin space is calculated to

thereby generate the magnification information and the

rotation angle information, it is not limited thereto.

For example, the coordinates transform processing may be

performed on a space detectable to the magnification

20   information and the rotation angle information.

[0172]   Though the first threshold th1 and the second

threshold th2 are fixed value, it is not limited thereto.

For example, the respective thresholds are variable

depending on an image pattern, so the matching processing

25   can be performed at a higher accuracy.